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The choice of planting material and methods in a National Replanting Programme**

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The average annual production of coconuts during the ten year period 1966-1975 has been 2645 million nuts. The quantity that was exported depended primarily on what was available after meeting domestic needs. Unless production per unit of land is increased we may soon cease to be an exporter of coconuts, and probably be reduced to the status of a coconut producing and consuming country.

A sample survey on coconut cultivation by the Dept. of Census and Statistics of Sri Lanka, 1970 (Table 1), gives the status of coconut in the main planting districts. Furthermore, it gives an indication of the extent of coconut 60 years and over and probably in need of immediate replanting. For the past 25 years or so, the Coconut Research Institute of Sri Lanka (CRI) has issued to the industry about 1.5 million seedlings per annum, sufficient for replanting or new planting about 8000 hectares (20,000 acres). Assuming that 50 per cent of the seedlings succumbed, the yearly increment of young coconut would be about 4000 hectares (10,000 acres). Even if the seedlings received the necessary care and attention, with the type of planting material used (*typica*, mother palm seedlings), economic returns would take at least 10 years from the date of planting.

Table 1. *Coconut acreages in the main planting districts*

District	*Extent under coconut (acres)*	*Extent 60 years and above (acres)*	*% 60 years & above*
Kurunegala	3,87,026	10,643	2.75
Puttalam	1,45,579	12,257	8.42
Kegalla	69,931	4,063	5.81
Colombo	2,19,998	8,514	3.87
Kalutara	37,652	982	2.61
Galle	37,090	333	0.90
Matara	37,278	2,189	5.88
Hambantota	51,667	1,575	3.05
	9,86,221	40,556	

Source—Sample Survey on Coconut Cultivation (1970). Dept. of Census and Statistics.

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We have been conscious of the need for producing improved planting material for the replanting or underplanting of existing coconut lands as well as new planting, in areas which may be termed 'new' to this crop. The breeder's objective of an ideal palm would be one that produces over 80 nuts and 18 kg (40 lb) copra per year. Other very desirable features would be a properly oriented crown of leaves, short bunch stalks and absence of leaf or bunch droop.

PLANTING MATERIAL

Selection is one of the oldest tools in the hands of the plant breeder and in the case of a perennial tree crop like coconuts it is essential that careful selection is practised, so that only the best available material is issued to the growers.

The advances made through mass selection in Sri Lanka have been described by Liyanage and Sakai (1960) and Liyanage (1967) and in India by Nambiar and Nambiar (1970). Liyanage and Sakai (1960) demonstrated that total weight of husked nuts per palm (which is an accurate indication of copra production per palm) has a very high heritability (0.95). Thus considerable genetic advance can be achieved in the cheapest possible way by selecting parent palms, which besides other desirable agronomic features, produce not less than 80 nuts and 18 kg (40 lb) of copra per year. Selection of mother palms for seed purposes is a four-stage process:—

(*a*) Selection of estates yielding over 12350 nuts/hectare/year (5000 nuts/acre/year)

(*b*) Selection of high-yielding blocks within the above estates.

(*c*) Selection of individual palms based on desirable agronomic features and yield.

(*d*) Selection of mother palms after the pick is completed where final assessment is based on number of nuts, shape and size and weight of nuts.

In the 1960's we built up a collection of 50,000 mother palms, mainly from the North-western Province. This has now come down to around 35,000 and in order to meet the demand for seedlings, it is necessary that we increase this collection. In order to reduce operational costs we are now investigating the potential of estates in the Southern and Eastern Provinces to feed nurseries in these two provinces as well as Sabaragamuwa. Most of the large coconut estates in the coconut triangle are now managed by the National Livestock Development Board and we would wish to solicit their continued support as well as the support of the Sri Lanka State Plantations Corporation and the Janatha Estates Development Board to ensure that nuts with the best genetic potential are used for seed purposes and not want only wasted for consumption. Selected planting material carefully nurtured may just about arrest the shortfall in productivity due to senility and the area going out of production on this score. Nevertheless, this is a slow process, and insufficient to meet the likely demand for coconut in the next few decades.

BREEDING FOR INCREASED YIELD

Breeding for increased yield commenced in 1950. A brief description of the parental types used in hybridization is given below.

Tall (Variety *Typica* form *typica*)	Dwarf (Variety *Nana* form *pumila*)
1. Tall in habit	1. Short, seldom attaining a height of over 10 metres (30 feet)
2. Late flowering, generally 6 - 8 years	2. Early flowering, generally 2½ - 4 years.
3. Cross-fertilizing	3. Self-fertilizing

4. Productive life 60 years or more	4. Productive life of 30 - 40 years
5. Standard planting density 158 palms/hectare (64 palms/acre)	5. 222 palms/hectare (90 palms/acre)
6. Nuts large, 4800 to a tonne of copra	6. Nuts small 8000 - 10,000 to a tonne of copra
7. Copra of good quality	7. Copra of poor quality
8. Reasonably tolerant to pests, disease and drought	8. Susceptible to pests (particularly black beetle and red weevil) and drought

After limited field trials, two promising strains produced by crossing the varieties 'tall' and 'dwarf' were offered to growers since 1960.

(*a*) CRIC 60 (*typica* × *typica*):— late-flowering and high yielding and suited to all areas where this crop is cultivated

(*b*) CRIC 65 (*typica* × *pumila*) or its reciprocal:— a hybrid strain which combines the early bearing character with yields that are not normally achieved with the former type particularly during the first 20 years or so.

Until such time that the technique of clonal multiplication of coconut has been proven, and shown to be a commercial proposition (and not merely an academic exercise), improved planting material can be produced only through controlled (hand) pollination or through the techniques of 'assisted' or 'directed' pollination in seed gardens. Controlled (hand) pollination is not really intended for purposes of commercial seed production, for it is laborious, costly, difficult to supervise and at times unreliable. Furthermore, it cannot meet even a fraction of the demand for improved planting material.

The cost of a hand pollinated seednut is about eight rupees and with 50 per cent selection in the nursery, the cost of production of a seedling may be about Rs. 16/-. Properly controlled seed gardens is the answer to mass production of quality seed, as has been recognized in India, Indonesia, Ivory Coast, Jamaica, the Philippines and Sri Lanka. Seedlings produced from a Seed Garden would cost considerably less as they are mass produced.

Sri Lanka's first Seed Garden initially set up for production of improved *typica* seed (Liyanage, 1961) and subsequently enlarged for production of *pumila* x *typica* CRIC 65 hybrids (Manthriratna 1976 a) should generate sufficient seed cheaply and effectively to cater to immediate replanting targets. From this year 43 hectares (105 acres) planted with hand pollinated *typica* x *typica* planting material, derived from what constituted the cream of mother palms in the Chilaw, Puttalam and Kurunegala districts will be systematically emasculated and allowed to pollinate with elite *typica* palms within the Seed Garden. This would mean systematic emasculation of about 5000 mother palms in the Seed Garden, which after subsequent natural pollination should give 400,000 seednuts or 250,000 seedlings each year, (Manthriratna, 1977).

Mass production of CRIC 65 hybrids follows the same pattern—dwarf (*pumila* and *eburnea*) palms are systematically emasculated and allowed to cross-pollinate with tall (*typica*) palms. An acre of seed garden containing approximately 70 *pumila* palms should yield 7000 hybrid seednuts, and even allowing for 50% rejections in the nursery, this should give 3500 seedlings sufficient for replanting 20 hectares (50 acres) of land. By 1982, it was expected that output from the Seed Garden should have become stabilised at 8000 hectares per annum. However, a combination of adverse circumstances, in particular a succession of droughts has resulted in a massive shortfall in production.

Successful replanting/underplanting of hybrids on 8000 hectares (20,000 acres) per annum is an ambitious target, which may be difficult to achieve even with the generous subsidies offered. Our Second Seed Garden with an effective area of 70 hectares (175 acres) is established on a different pattern in that a high-yielding plantation is interplanted with dwarf (*pumila*) planting material to be subsequently emasculated and allowed to fertilize with random tall (*typica*) pollen. The Second Seed Garden is really a form of insurance, in case productivity at the First Seed Garden were to fall due to pest or disease, drought or even acts of god!

HYBRID PERFORMANCE UNDER FIELD CONDITIONS

The yield data for CRIC 65 hybrids planted at Ratmalagara and Pothukulama Research Stations and Bandirippuwa Estate is given in Tables 2, 3, 4, and 5.

Table 2. *Yield of Typica* × *Pumila* F_1 *hybrids*

1. Ratmalagara Research Station
   (*a*) Year of planting-1950. No. of progenies 22.

Year	*Nuts/Palm*	*Calculated yield per hectare (158 palms)*	*(4 years avg.) per acre (64 palms)*	*Total wt. of husked nut (lb)*	*Wt. per nut (lb)g.*
1955	(Not more than 4-6 bunches harvested)			—	—
1956	68			100.6	1.56 708
1957	86			122.7	1.43 652
1958(8th)	65	8690	3520	110.5	1.70 765
1959	103			147.8	1.43 652
1960	102			187.7	1.84 830
1961	129			225.6	1.75 794
1962(12th)	144	18960	7680	284.1	1.97 907
1963	165			297.9	1.80 822
1964	151			276.7	1.83 830
1965	180			295.8	1.64 744
1966(16th)	171	26386	10688	262.2	1.53 694
1967	135			202.9	1.50 680
1968	120			181.8	1.51 684
1969	135			210.8	1.56 708
1970(20th)	137	20856	8448	205.4	1.50 680

(Contd.)

1971	160			250.1	1.56 708
1972	151			223.8	1.48 671
1973	131			176.2	1.35 612
1974(24th)	127	22436	9088	177.8	1.40 624
1975	not available			—	— —

Table 3. *Yield of Typica* × *Pumila* F_1 *hybrids*

2. Ratmalagara Research Station

(*b*) Year of planting — 1958. No. of progenies 225
Planting distance : Hedge 8 x 5.5m (26′ x 18′)
density: (initial) — 229 palms/hectare, 93 palms/acre
density: (final) — 158 palms/hectare, 64 palms/acre

Mean yield — nuts/palm

Year	*Yield*	*Year*	*Yield*
1963(5th)	25	1971	102
1964	26	1972	116
1965	63	1973(15th)	56
1966	34	1974	figures not available
1967	50	1975	figures not available
1968(10th)	65	1976	84
1969	65	1977(19th)	117
1970	75		

Note: Plantation thinned out to conventional density in 1969/1970 (Low yields in the early years may be due to overcrowding)

Table 4. *Yield of Typica* × *Pumila* F_1 *hybrids*

3. Bandirippuwa Estate

(*a*) Year of planting 1963 - (*b*) No. of progenies 156
Planting distance: 7.3 x 7.3 m (24′ x 24′)
density: initial — 187/hectare (76 palms/acre)
density: final — 158/hectare (64 palms/acre)

Planting system — underplantation with progressive removal of the old stand of palms.

Year	*Yield per palm (nuts)*	*Yield per hectare*	*Yield per acre*
1972(9th year)	91	14378	5824
1973	63	9954	4032
1974	102	16116	6528
1975	104	16432	6656

Table 5. *Comparative study of typica × pumila, typica × typica, and typica (O.P.) progeny at Pothukulama Research Station*

Year of planting	1963
No. of progenies	144 per cross
Planting distance	7.6 x 7.3m (25′ x 24′)

Planting Material	*Yield during 5th year nuts*	*Cumulative yield 1967-1976 nuts*
Typica × pumila	3362	73,304
Typica × typica	1644	65,354
Typica (O.P.)	995	60,057

Note: *Typica* (O.P.) represents the best available progeny from selected palms used for controlled pollination work. These palms are of a higher yield status than those selected as mother palms as sources of seed for producing selected seedlings.

As research findings from carefully controlled field experiments with optimum inputs of fertilizer and management are not duplicated under farmers' conditions, CRIC 60 and CRIC 65 hybrids have been given an extensive try-out largely in the hands of coconut growers in practically every district where this crop is grown. Out of 60 such "Observation Plots", about 30 are still functioning and the indications from these trials are that while CRIC 60 is suitable for all areas where coconuts can be grown, the CRIC 65 hybrid is more restricted in its use and better suited to sandy-loams, sandy clay-loams and loamy soils in those areas receiving at least 1500 mm (60 inches) of rain annually and without prolonged dry spells. By relating hybrid performance with soil characteristics, a broad classification of land areas suitable for hybrids has been made (Table 6), the suitable soils being mostly red-yellow podsolics, together with some regosols and latosols (Division of Soils, CRI). A further classification taking into account soils and rainfall (Table 7) reveals that, *with the existing knowledge of hybrid performance under different agro-climatic conditions*, not more than 110,500 hectares (273,000 acres) can be effectively brought under hybrids.

Table 6. *Classification of land areas suitable for hybrids*

Province	*District*	*Existing area under coconuts (acres)*	*Total suitable area for hybrids in terms of soil (acres)*
North Western	Kurunegala	387,026	382,412
,,	Chilaw/Puttalam	145,579	64,845
Western	Colombo	218,998	56,628
,,	Kalutara	37,652	13,179
Southern	Galle	37,090	78.246
,,	Matara	37,278	65,167
Sabaragamuwa	Kegalle	69,931	94,925
Central		20,931	2,581
	Total	965,475	757,983

Source: Soil Survey Unit, Division of Soils, CRI, Lunuwila.

Table 7. *Land area suitable for hybrids*

Province	*District*	*D.R.OO Division*	*Approximate Acreage*
North Western	Kurunegala	Katugampola Hatpattu	68275
		Devamedi Hatpattu	8094
		Hiriyala Hatpattu	8459
		Wendawili Hatpattu	32691
		Dambadeni Hatpattu	51442
	Puttalam	Demala Hatpattu	Nil
			168961
	Chilaw	Pitigal Korala North	12654
		Pitigal Korala South	17295
			29949
NWP—Total Acreage			198910
Western	Colombo	AKK North A	9109
		AKK North B	3925
		Hapitigam Korale	8027
		AKK South	2209
		SK East	4826
		Hewagam Korale	2663
		Salpiti Korale	475
			31234
	Kalutara	Raigam Korale	1679
		Pasdun Korale West	267
			1946
Western Province—Total Acreage			33180
Southern	Galle	Bentota Wellaawita Korale	844
		Gangaboda Pattuwa	933
		Four Gravets	1861
		Talpe Pattuwa	3443
			7081
	Matara	Weligam Korale	2064
		Gangabada Pattuwa	1575
		Wellaboda Pattuwa & Four Gravets	6236
		Kandokoda Pattuwa	2385
		Morawak Korale	112
			12372
Southern Province—Total Acreage			19453

Sabaragamuwa	Kegalle	Beligal Korale	14794
		Galaboda & Kiniboda Korales	4000
		Pannakuru Korale	306
		Dehigampola Korale	2372
Sabaragamuwa Province—Total Acreage			21472
Central	Kandy	Tumpane	346
Total acreage for hybrids *ALL PROVINCES*			273,361

When more data are available, particularly from the Northern, North Central and Eastern Provinces, where hybrids are grown with and without irrigation, it may be possible to expand the area under hybrids. Until then, judicious use must be made of our limited sources of improved planting material.

SELECTIVE USE OF AVAILABLE PLANTING MATERIAL

In the choice of planting material for a National Replanting Programme it is important that:—

(*a*) CRIC 65 hybrids are used in the areas demarcated in Table 7 for under intensive care and adequate management they could maximise yield.

(*b*) CRIC 60 be used within the coconut triangle, where due to the soil factor it may be inadvisable to grow CRIC 65 hybrids.

(*c*) Selected *typica* mother palm seedlings be used in the intermediate and dry zones, where the cultivation of the crop could be best described as marginal, but where nevertheless it is important to fulfil domestic needs, (Manthriratna, 1975).

Local selection of mother palms in the dry zone to feed these areas may be another fruitful line of approach though the inheritance of drought resistance (tolerance?) in this crop has yet to be understood.

PLANTING TECHNIQUES

Use of improved planting material is only one aspect of the battle for increased production. Efficient management—cultural practices, fertilizer use, pest and disease control are other vital aspects.

Planting systems and densities

It has been customary to plant coconut on the corners of a rectangle, triangle or square. There are reports on other systems such as contour planting, hedge planting (Liyanage, 1955), and double-hedge planting (Shanmugam, 1975). The planting system used and the inter-plant spacing could give a range of densities. Generally 150 - 175 palms per hectare (60 - 70 palms per acre) are grown with coconuts in mono-culture. Wider spacings are employed for permanent intercropping *e.g.*, a spacing of 9m × 9m (30′ x 30′) for the coconut/cocoa combination in Malaysia. From the results of a coconut spacing trial at the Pothukulama Research Station, where densities of 45, 51, 60, 80, 96 and 116 palms per acre (111 to 297 palms per hectare) have been used, it was shown that short term food crops can be grown economically even at the higher densities of coconut during the juvenile phase of the palms, (Karunaratne *et al*, 1976). Furthermore, it would appear that 10.7 x 7.3m (35′ x 24′) is a useful planting system for permanent intercropping and a firm recommendation may be possible in a few years (Manthriratna, 1976b). Likely crop interactions and competition for light, soil moisture and nutrients and the conditions of the micro environments under coconut palms need to be evaluated.

Methods of rejuvenating coconut lands. Underplanting vs. replanting

Debate never ends on the merits of the above systems as well as the time honoured technique of gradual and perpetual replacement of senile and dud trees. We do not have sufficient experimental data on this topic which even seems to defy field experimentation. Our recommendations largely stem from one field experiment on methods of replanting senile coconut plantations (Liyanage, 1963) as well observations made by the plantation sector. It would appear that the choice to underplant, replant or replace duds as a means of rejuvenating unproductive coconut lands would largely depend on the extent of the land. A large estate could perhaps afford to phase out its programme and replant a division or large block every eight years. This would not seriously affect its income nor upset its other ventures such as animal husbandry or intercropping. A smallholder is faced with a different problem. He cannot afford to lose his entire crop from the old stand by resorting to replanting. He will carry out the operation of gradual removal of old unproductive palms with a certain amount of misgiving. Can gradual replacement be effectively used? If so what happens if hé has livestock? Can he afford individual fencing of supplies?

We are aware of the damage that has been done to the second plantation as a result of the reluctance to pull down the old stand—delayed flowering, lengthy trunks out of proportion to the age of the palms, spindly leaves with short leaflets. It has been the usual practice to blame the CRI saying "Your seedlings have still not borne a single fruit although they are ten years old!" when the real reason is agricultural mismanagement!

Size of seed-hole and depth of planting seedlings

The current recommendation is a 1m x 1m x 1m (3′ x 3′ x 3′) seed-hole. Due to the cost factor, the 1.2m x 1.2m, x 1.2m (4′ x4′ x 4′) seed-hole recommended for hard gravelly soils is seldom seen. An experiment comparing the size of seed-hole and growth, flowering and yield, was unfortunately not replicated in different agro-climatic regions. However, there was no difference in the performance of palms planted in seed-holes whose cubic capacity varied widely. We have planted large acreages on sandy loams using 30cm x 30cm x 30cm (1 x 1 x 1 cu feet) seed-holes with no ill effects. However, while the recommendation of the 1m x 1m x 1m (3′ x 3′ x 3′) seed-hole for most areas still holds good, we would like to hear the experience of the planting community gathered here. Depth of transplanting seedlings is an equally controversial subject. Sixty or seventy years ago, deep planting was common, and at least in Colombo District, planting at a depth of 60 cm (2 feet) was regularly practised. This resulted in straight trunks, absence of bulging boles above the ground, few aerial roots from the base of the trunk, resistance to gale-force winds and an appreciable amount of drought tolerance. Surface planting leads to a prominent bole above the ground, twisting trunks, susceptibility to strong winds and drought. It is recognised that surface planting leads to early flowering. Are we sacrificing other useful attributes resulting from deep planting for the initial advantage of early flowering, the difference being of the order of 12 - 18 months? Deep planting is a common practice in Kerala State, South India, and root studies of the coconut palm as well as several intercrops have shown the distribution patterns of roots of coconut as well as the intercrops (Nelliat *et al*, 1974). The distinct zonation of roots may perhaps be an advantage for intercropping, and as permanent intercropping may be the pattern of the future, depth of planting and root formation need further study.

Age of transplantation

This is another aspect that needs investigation for we feel that there cannot be a "golden-rule" applicable for all areas. Generally CRI seedlings are issued when they are about 9 - 11 months old (from date of sowing) and in the "third leaf" stage. However, for low-lying areas resembling 'deniyas' with a high water table and probably subjected to water logging during the monsoons, coconut growers prefer 18 - 24 month old seedlings and they claim that establishment is better and quicker. In countries where poly-bag seedlings are issued from nurseries age at transplanting is not so critical. Perhaps the plantation sector may enlighten us with their experiences.

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